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Title: Risk- and Variance-Aware Electricity Pricing

Abstract: A low-carbon or decarbonized power grid of the future requires a robust and efficient marketplace to deal with stochastic renewable energy sources (RES). While advances in power transmission, conversion and control have addressed many, if not all, technical concerns about rolling-out RES at scale, market practices lag in internalizing uncertainty and risk, which inhibits efficient RES usage and allocation. We propose a stochastic market-clearing framework on retail (distribution) and wholesale (transmission) levels that produces uncertainty- and risk-aware prices for active and reactive power and balancing regulation. Derived from the chance-constrained AC optimal power flow using conic duality theory, these prices reflect co-optimized power production levels, system reserve and its allocation to guarantee real-time deliverability given the physical state of the grid and desired risk-parameters of the system operator. Using a suitable penalty metric, we extend the risk-aware price formation process to internalize the variability (variance) of system state variables. The resulting risk- and variance-aware pricing framework provides comprehensive insights on the price formation with stochastic RES and can assist in rolling out stochastic electricity wholesale and retail markets in compliance with real-time operations.

Key words: Electricity Markets, Stochastic Optimization, Conic Duality, Risk Management